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(54) Double Top Chord

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ABSTRACT

A steel joist is disclosed consisting of a web, a bottom chord and a double top chord construction consisting of two elongated substantially identical portions each being of S or Z cross-section and being connected to or integral with the web.

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The present invention relates to improvements in steel joists and composite steel and concrete construction systems. The present invention constitutes an improvement upon the applicant's prior invention patented in U.S. Patent No. 3,845,594 on November 5, 1974.

The present invention discloses an improvement on the aforesaid patented structure in which a composite steel and concrete structure comprises a horizontal concrete slab containing reinforcing mesh and surmounting and partially embedding a plurality of steel joists. Each joist has a top chord and a bottom chord which are connected by a web. The improved joist of the present invention includes a pair of symmetrical oppositely positioned S or Z shaped flanges, extending the length of the joist and connected to the web. In such a joist, the web may be of the well-known zig-zag or continuous type of open web, or the web may be composed of a plurality of structural shapes connected together to form an open truss structure between the top and bottom chords.

In an alternative form of the invention, the web may be constructed of solid sheet material, either integral with or separate from the top and bottom chords of the steel joist.

The present invention constitutes a significant advancement and improvement on applicant's prior patent as aforesaid, and in particular, provides a joist possessed of greatly superior properties in comparison with prior art joists. Among such properties is a significant improvement in lateral stiffness

which greatly improves the strength of the composite structure during the construction stages and permits safer construction procedures particularly where long spans are involved. Thus, applicants are able to erect long span constructions in excess of the present limit of 13 meters, and may extend these spans to 20 or 25 meters without difficulty. By utilizing angles, channels or tubes for web members, it is possible to increase the radius of gyration of these sections over a solid round section and thus higher unit stresses may be tolerated in the web members and a saving in steel weight results in a more efficient joist construction.

The joist of the present invention may be constructed from high strength steel, and incorporated into a structure which possesses a two hour fire classification rating. This is a matter of great significance in the advancement of composite construction, as safety considerations are of ultimate importance in any building intended for use for residential or office purposes.

The joist of the present invention is symmetrical about the vertical axis of the joist, which symmetry provides structural advantages during the non-composite or installation stage, where the unpropped joist is required to carry the weight of wet concrete, form work, its own weight and other construction live loads that may be imposed, such as the weight of workmen, or possible excess concrete due to localized thickness or impact of concrete pouring buckets. The double top chord profile

provides a greater cross-sectional area in this critical component of a long span joist, which improves it lateral slenderness properties thereby making it stiffer. This increased stiffness increases the capacity of the joist to resist compressive stresses. Correspondingly this reduces the degree of lateral restraint that need be provided to the top chord or top flange during the construction stage, which lateral restraint is normally provided by a combination of roll bars and plywood form work securely attached to lateral supporting wall beams and the like. There are clear economic advantages to this improved performance of the joist, resulting in cost savings during the erection of composite steel and concrete floor systems, which savings may be translated into lower cost per square foot of floor space which may be passed on to owners and occupants in the form of reduced capital costs, reduced rents and the like. Also, the joist of the present invention being symmetrical provides significant improvements in the fabrication stage, since distortion caused by heating during welding procedures is minimized.

Sweep is a phenomenon encountered when constructing a welded joist, where the welds all occur on one side of the web. This creates a stress in the joist which tends to cause a curvature to occur in the completed joist. This curvature has been overcome in present practice by pre-curving the top chord in a direction opposite to the direction in which the sweep will occur, so that the completed joist when welded together returns to a substantially straight longitudinal configuration.

With the symmetrical properties of the joist of the present invention, the entire problem of sweep due to welding stresses is avoided, and a straight joist is obtained without the necessity for complicated precompensation techniques during fabrication.

All of the above advantages mean that the joist of the present invention when compared with applicant's prior structure is even more stable laterally and torsionally during the non-composite stage, and accordingly longer spans may be more safely constructed than were possible in accordance with the prior art.

In the accompanying drawings:

FIG. 1 is a perspective view from below of a composite construction utilizing joists of the present invention,

FIGS. 2A and 2B are vertical sections through joists constructed in accordance with the present invention illustrating alternative arrangements of the top chord members,

FIGS. 3A, 3B, 3C and 3D illustrate features of joists in which the web is a continuous sheet, and

FIGS. 4A, 4B, 4C, 4D, 4E and 4F illustrate further details of top chord to web connections, and joist fabrication techniques.

With reference to Fig. 1 of the attached drawings, there is shown a composite steel and concrete floor system 10 consisting of a plurality of open web joists 11 connected together with roll or spanner bars 12, which serve to support form work 13, on which a concrete slab 14 is poured, which slab includes reinforcing mesh 15. Each of the open web joists 11 consists of a bottom chord 16, which as shown in Fig. 1 may consist of a pair of right angled

members 16, a series of web members 17 and dual top chords 18. The top chords are provided with appropriate slots through which the roll or spanner bars may be inserted to support form work, the roll or spanner bars being either permanent roll bars intended to remain in the structure when complete, or may be removable roll bars as taught for example in applicant's prior U.S. Patent No. 3,945,168.

Referring to Fig. 2A there is shown in vertical section, an open web joist 11 having a pair of bottom angles 16, forming the bottom chord of the joist, a pair of top chord members 18, and a web which may be for example formed of hollow rectangular cross-section tubular members, or of channel members 17. As illustrated in Fig. 2A the two top chord members are welded together at 19 and to the web members 17 by welds 20. The welds 20 as illustr-ated may be spot or seam welds, and are positioned to provide the maximum strength, and to enable a welding electrode to be inserted inside the member 17, to make a satisfactory weld. Each top chord member 18 is formed of an identical cross-section profile shape having an upper S or Z portion 21 and a downwardly depending leg 22. As in applicant's prior patents, it is intended that the S or Z shaped portions 21 be embedded in the concrete slab of the composite construction, the S or Z shapes providing a superior shear connection between the concrete slab and the joists to provide a true composite action between the joists and the slab. It should be noted that the two top chord members are positioned in mirror image relationship to one another, thus providing a perfectly symmetrical configuration of joist about a vertical

axis. The advantages of such symmetry are detailed hereinbefore.

Fig. 2B illustrates a similar joist constructed in accordance with the present invention, also possessed of vertical symmetry, but in which the top chord members are arranged facing oppositely to the members in Fig. 2A. As before the top chord members are secured to the web 17 by suitable welds 20, and an additional filler plate 23 is secured between the top chord members 18, and serves to seal the space between the two top chord members to prevent the loss of concrete through the open web of the joist, during construction. The function of the two embodiments illustrated in Figs. 2A and 2B is virtually identical.

Fig. 2B also illustrates an optional form of top chord member 18, which may be provided with an optional lip 24, which is useful for increasing the compressive strength of the joist in the non-composite mode, that is before the top chord has been embedded in concrete.

Fig. 3A illustrates in perspective an alternative form of joist in accordance with the invention in which the web and bottom chord are rolled from a single strip of steel. The web 37 of Fig. 3A is formed unitarily with the bottom chord 36, for example by the cold rolling of a suitable strip of sheet steel. As before, top chord members 18 are connected to the web 37 by welding, and opening 38 in the top chord and the web may be formed either before or after welding by a suitable punching operation. It will be appreciated that if the slots 38 are formed before the top chord members 18 are welded to the web 37, it will be necessary to

provide means for aligning the openings 38 which extend entirely through both top chord members and the web 37 prior to welding. This alignment may create problems in fabrication in certain circumstances, and accordingly Fig. 3B illustrates an alternative to the structure illustrated in Fig. 3A in which the top chord members 39 are provided with only a very short downwardly depending leg 40 on the cross-sectional shape which leg is, as before, welded to the web 37. In this case, the web may readily be punched for the openings 38 prior to affixing the top chord members 39, and there is no necessity to align openings in the top chord members with corresponding openings in the web.

Fig. 3C illustrates in exploded perspective an alternative form of joist construction in accordance with the invention. In Fig. 3C the joist is formed of a strip or plate 41 angles 42 as bottom chords and top chord members 43. The joist of Fig. 3C is fabricated by welding, and appropriate slots are formed in the top chord members 43 and in the web 41 prior to or after welding, with the necessary alignment being made so that the openings 44, 45 and 46 in the top chord members 43 and the web 41 would be appropriately aligned prior to running the welds.

Fig. 3D illustrates an alternative form of bottom chord 47, which can be used in place of the angles 42 of Fig. 3C. In this case a cold rolled steel bottom chord shape as shown in Fig. 3D would be attached to the web 41 as by welding.

Fig. 4A illustrates a form of top chord member 50 provided with a longitudinal rib 51 on the vertical leg 52 of the top chord

section, which rib 51 would assist in electric resistance welding of the top chord member 50 to an appropriate web structure.

Fig. 4B illustrates an alternative form of top chord member 53 provided with a plurality of slots 54 in the sloping face of the top chord section to enhance the shear connection between the top chord and the concrete slab by permitting concrete to fill the slots 54 when the slab is being poured.

The top chord member 53 is also provided with a right angle flange 55 which may be used to support appropriate form-work, as an alternative, or ancillary to the use of conventional spanner or roll bars.

Figs. 4C and 4D are perspective views illustrating the use of channel shapes as web members 60, which web members may be positioned centrally of the joist as in Fig. 4D, wherein the channel member 60 is positioned between the vertical legs 61 and 62 of the open web joist. In Fig. 4D where heavier construction loads are to be encountered, the vertical legs 61 and 62 of the top chord members are positioned tightly together, and channel web members 60 are positioned on either side of the vertical legs 61 and 62. Similarly, bottom chord members 63 shown in Fig. 4D as angle members may be positioned between the web members 60.

A further and highly desirable fabrication practice is to use channels for all compression members of the truss or open web joist, which are positioned inside or between the top chord members, and to use angles for tension members, which are

positioned outside the top chord flanges.

Figs. 4E and 4F illustrate two additional fabrication techniques. In Fig. 4E two identically shaped members 70 and 71 are welded back-to-back to provide a complete joist. Each member 70 and 71 is one half of the completed joist, the joint between the two members coinciding with the vertical axis of the completed joist. In Fig. 4F a first member 72 includes an S or Z shaped top chord 73, a bottom chord portion 74, and a web 75. A second top chord portion 76 is welded to the web 75 to form the completed double top chord joist.

Thus summarizing, the present application discloses an improved composite steel and concrete floor system, utilizing a novel form of joist having a pair of symmetrically opposed top chord members connected to a suitable web which in turn is connected to a suitable bottom chord structure. The applicant's top chord now consists of two S shaped members which may be identical to those taught in applicant's prior patents with the exception that the downward vertical leg is modified in that it may be lengthened to provide the required additional welding surface for web connections. The lip in the present top chord construction may be either deleted or rolled in the opposite direction if necessary so as not to interfere with web members which are placed between or outside the top chord elements.

In the alternative, some web members may be located between the top chord elements and some outside the top chord elements. This option has definite advantages so far as welded connections

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are concerned in order to more easily align the web and chord members. The top chord member of the present invention is stronger than the prior top chord since the joist is symmetrical about its vertical axis. The downstanding legs of the top chord elements may of course be extended to increase welding surface area as required.

Insofar as slots are concerned, which are provided so that roll or spanner bars may be inserted therein to support form work, the function of these slots is unchanged from the teachings of prior patents. However the long ends of the roll bars of the prior art should be cut back so that they do not foul the opposite top chord element when being inserted during erection of a composite floor system. Alternatively further saw cuts may be made in the roll bar to accommodate the vertical flanges of the double top chord structure.

The web system of the present invention may be constructed of individual members which can be any shape conventionally used for such members. Commonly angles, flats, channels and rectangular sections may be used, although round rod pieces or serpentine web could also be used if required for any particular application. The bottom chord of the joist may be of any conventional shape although generally a pair of angles is the most commonly encountered configuration.

The cover or fillet plate used to fill the top of the joist between the top chord members may be made of very light gauge material and its purpose is simply to prevent concrete from

spilling through between the top chord elements. The uppermost portion of the individualy web members is positioned so that it does not protrude above this cover plate. It would be logical to make the cover plate of light gauge steel and simply tack weld it into place. It would be considered a non-structural element and thus not included in the design calculations for the joist. Alternatively, however, a heavier cover plate could be utilized and welded into position to provide a more positive lateral connection between the top chord elements than that which would normally occur as a result of the top chord to web member welded connections. This heavier cover plate might then be included in the design calculations for the load bearing strength of the joist.

In general, the advantage of the applicant's improved joist structure is a great increase in lateral stability as result of the double top chord elements which are connected together by either web connections or a heavier gauge filler plate. The increased lateral stability or rigidity reduces the slenderness ratio of the top chord element and provides additional compression capacity during the non-composite structural stage of construction. Furthermore, the addition of a second top chord element provides increased cross-section area further enhancing the compression capacity of the joist. Thirdly the configuration now allows individual web members to be utilized more readily and provides for a more efficient web system which is lighter in weight especially in the longer spans of 35 feet and over, enabling the double top chord joist of the present application to be utilized in spans of 60 feet or more.

SUPPLEMENTARY DISCLOSURE

The fabrication technique illustrated in Fig. 4E provides a particularly advantageous technique in practicing the present invention. The symmetrical sections may be rolled, welded and punched to provide an economical and versatile joist for use in composite construction.

When fabricated as a shallow depth joist an efficient in-fill technique for steel beam structures is obtained. If a deeper joist is formed, an efficient regular span joist is obtained:

In drawings which further illustrate the invention:

Fig. 5 is a perspective of an in-fill framing system using joists the cross-section of which is shown in Fig. 4E, and

Fig. 6 is a section through a composite steel and concrete construction in accordance with another aspect of the present invention. Referring to Fig. 5, there is shown a portion of a building floor system, including steel beams 80 and 81 supporting a pair of double top chord joists 82 and 83. Spanner bars 84 and 85 as taught in prior U.S. Patent No. 3,845,594 connect the joists 82 and 83 and would support suitable sheeting (not shown) on which a concrete deck slab may be poured. Thus a smooth concrete slab may be poured, forming the floor of a building with a steel beam subframe.

In Fig. 6, a pair of steel beams 90 and 91 support ledger angles 92 and 93 on which a joist 94 is shown, embedded in and supporting a concrete slab 95. By the use of the ledger angles

92 and 93, a thickened slab may be obtained compared to the slab of Fig. 5, which may for example be used for an in-floor electrical distribution system (not shown).

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A composite steel and concrete structure comprising a horizontal concrete slab containing reinforcing mesh and surmounting and partially embedding a plurality of steel joists; each joist having a top chord, and a bottom chord which are connected by a web; said top chord comprising a pair of symmetrical, oppositely positioned S or Z shaped flanges extending the length of said joist and being embedded in said concrete slab, the web and bottom chord portions of said joist not being embedded in said concrete.

2. A composite structure as claimed in Claim 1, wherein each of said S or Z shaped flanges has a downwardly depending leg and is connected to said web by welding said leg and said web together.

3. A steel joist for use in a composite steel and concrete floor system, said joist comprising a top chord, and a bottom chord joined by a web, said top chord comprising two substantially identical elongated rolled steel members, each member being of S or Z cross-section, with a downwardly-depending leg, said two shapes being attached to said web by welding said downwardly-depending leg of each top chord member to said web, the two top chord members being arranged in mirror image relation to one another; said S or Z portions of said top chord members of said

joist being adapted to be embedded in a concrete slab to develop composite action with said slab.

4. A steel joist as in Claim 3, wherein the downwardly-depending leg of each of said top chord members is welded to said web, said legs of said top chord members further being provided with a plurality of longitudinally spaced openings therein adapted to receive the ends of spanner bars to support concrete retaining forms on said spanner bars.

5. A steel joist or truss comprising a top chord, a bottom chord and a web joining said top chord and said bottom chord, said top chord comprising a pair of S or Z shaped members adapted for embedment in a concrete slab, said members being positioned in mirror relation to one another thereby providing a joist having symmetry about a vertical axis.

6. A joist as claimed in Claim 5, wherein said web is comprised of a continuous serpentine bar.

7. A joist as claimed in Claim 5, wherein said web comprises a plurality of channel shaped compression members and angle shaped tension members.

8. A joist as claimed in Claim 5, wherein said web comprises a sheet or plate.

9. A joist as claimed in Claim 5, wherein said bottom chord comprises a pair of angle members connected to said web by welding.

10. A joist as claimed in Claim 9, wherein said angles are connected to said web by welded connections.

11. A joist as claimed in Claim 5, wherein said bottom chord is integral with and rolled from a single piece of steel together with said web.

12. A joist in accordance with Claim 5, wherein openings are provided adapted to receive spanner bars to support form work during erection of a composite steel and concrete structure.

13. A joist as claimed in Claim 5, wherein said joist is formed of two identical cross-section members joined at said vertical axis.

14. A steel joist for use in composite steel and concrete construction, said joist having a top chord adapted to be embedded in a concrete slab to form a shear connector to said slab, a web, and a bottom chord, said joist being formed to two identically shaped members joined back-to-back, with each member having one half of the top chord, web and bottom chord formed therein, said members being formed of rolled sections of sheet steel.

15. A joist as claimed in Claim 14, wherein said top chord consists of a pair of S or Z cross-section shapes.

CLAIMS SUPPORTED BY THE SUPPLEMENTARY DISCLOSURE

16. A structure as claimed in Claim 1 wherein said joists are supported by steel beams and together with said slab form an in-fill panel.

17. A structure as claimed in Claim 16 wherein each of said joists is formed as claimed in Claim 14.

18. A structure as claimed in Claim 16 wherein said beams are provided with ledgers fixed to the webs thereof whereby a thickened slab is obtained.

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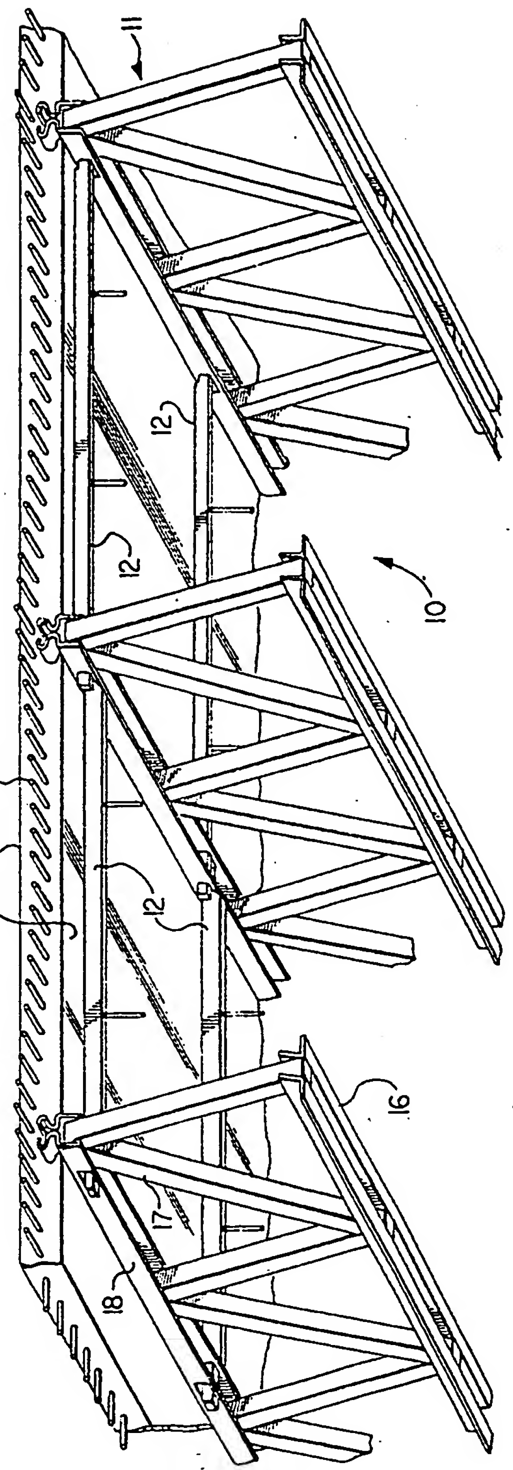

FIG. 1

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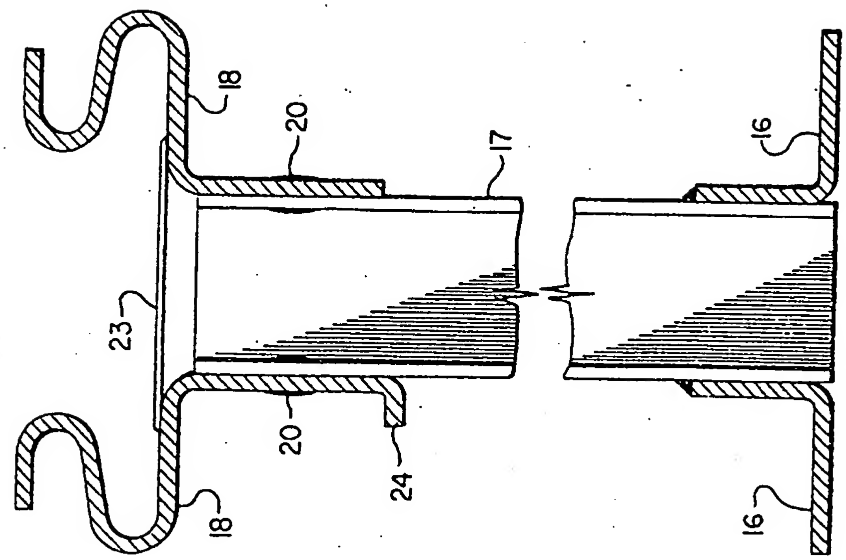

FIG. 2B

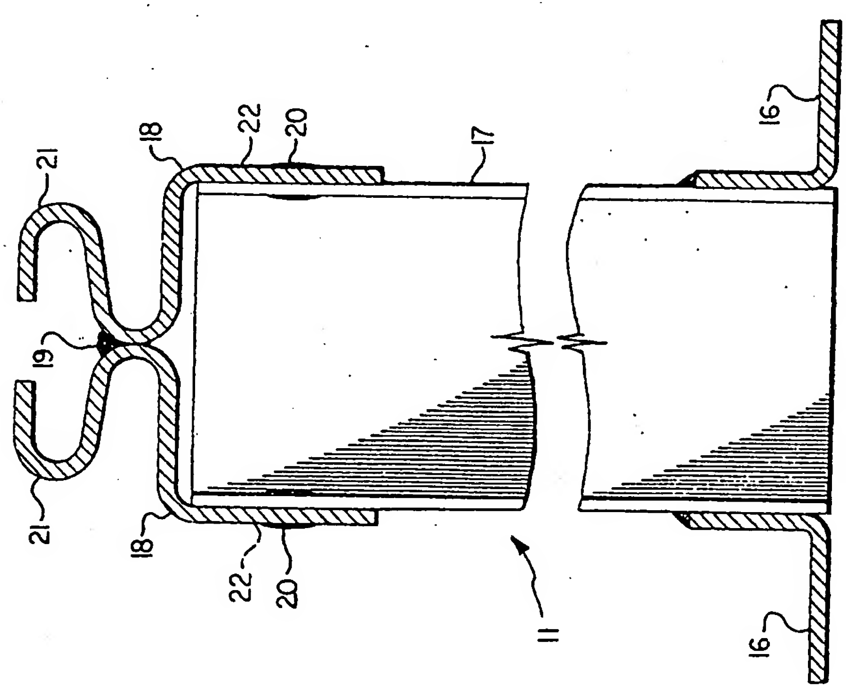

FIG. 2A

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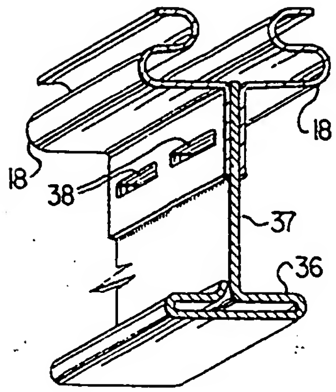

FIG. 3A

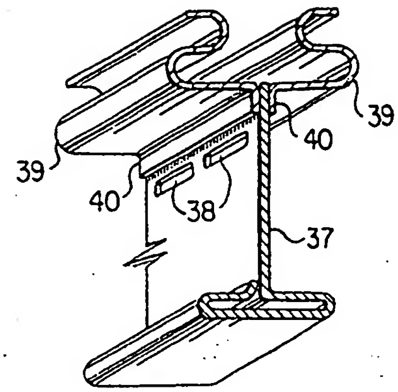

FIG. 3B

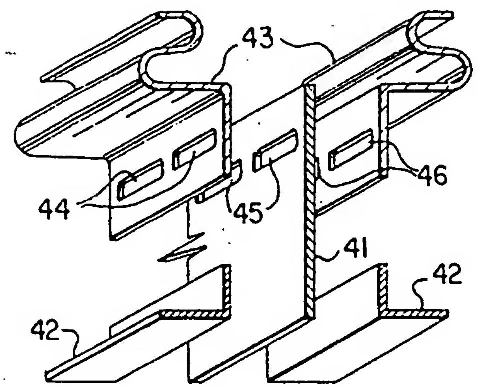

FIG. 3C

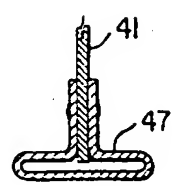

FIG. 3D

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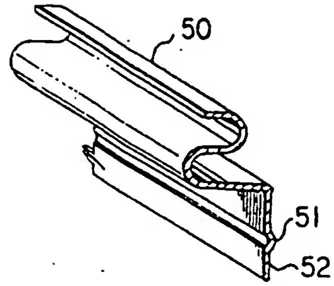

FIG. 4A

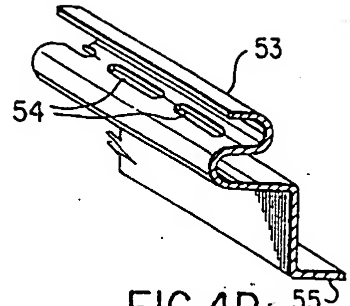

FIG. 4B

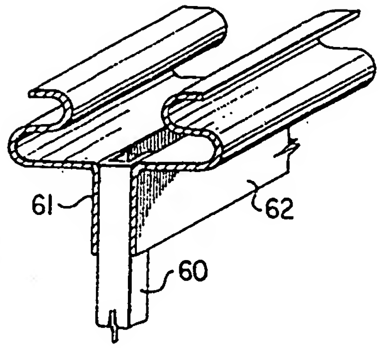

FIG. 4C

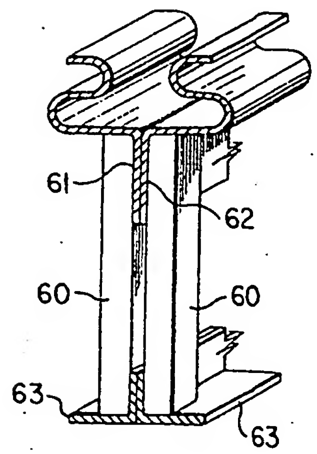

FIG. 4D

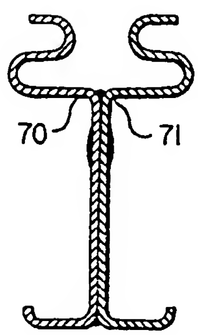

FIG. 4E

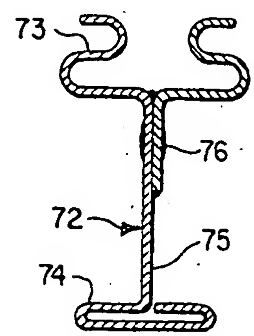

FIG. 4F

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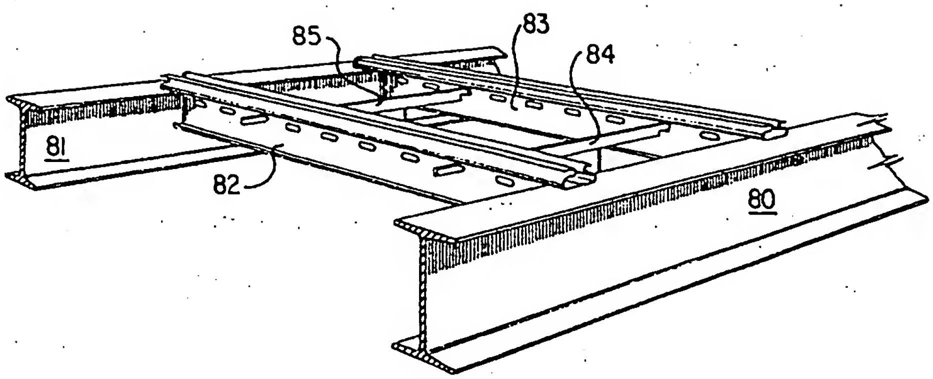

FIG. 5

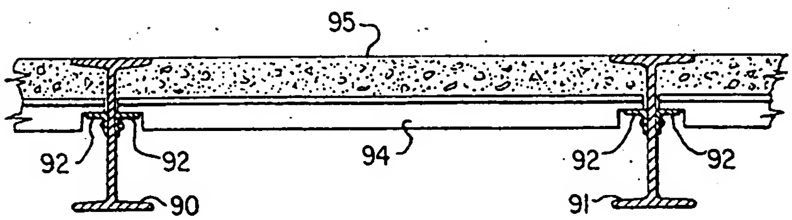

FIG. 6

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